

TITLE OF THE INVENTION

CONTACTOR, METHOD FOR MANUFACTURING THE SAME, AND PROBE  
CARD USING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

5           This application is based upon and claims the  
benefit of priority from the prior Japanese Patent  
Application No. 2000-345577, filed November 13, 2000,  
the entire contents of which are incorporated herein by  
reference.

10                   BACKGROUND OF THE INVENTION

1. Field of the Invention

15           The present invention relates to a contactor used  
to test an object to be tested for its electric  
characteristics, a method for manufacturing the  
contactor, and a probe card using the contactor.

2. Description of the Related Art

20           To test the electric characteristics of many  
subjects to be tested, for example, IC chips such as  
memory devices or logic devices formed on a  
semiconductor wafer (hereinafter called "wafer"  
simply), a probe card having a contactor can be used.  
In testing, by contacting the contact terminals (probe  
needles) of the contactor of the probe card to the  
corresponding electrode pads of the IC chip, the IC  
25           chip can be electrically connected to a tester.  
By this connection, a testing signal can be received  
and transmitted between the two. The contact terminals

of the contactor of this probe card may be,  
for example, probe needles made of tungsten.

Recently, with the ever increasing integration  
density of an IC chip, its electrode pads have rapidly  
become numerous, shrunk in size, and narrowed in pitch.  
Since the probe needles made of tungsten employed in  
a probe card are made manually, its manufacturing costs  
increase and its delivery time limit is prolonged in  
proportion to the number of the pins used.

To meet a demand for reduction in the testing  
costs, there has been commercially available such  
a multi-chip contactor that enables simultaneous  
measurement of a plurality of IC chips. For example,  
there is a case where the number of contact terminals  
of the contactor for testing a logic device exceeds  
2000. In the case of testing a memory device, there is  
a demand for increasing the number of devices to be  
measured simultaneously from 32 to 64. From this  
viewpoint, it is expected that the number of the  
contactor pins exceeds 5000 in the near future. As the  
pad size has decreased, it has been more and more  
difficult to manufacture the probe card.

The necessity of reserving a proper needle  
pressure for a probe card using tungsten-made needles  
limits the shortening of the needles. This is due to  
the Young's modulus, assembly, etc. Since the length  
of the needles has an influence on the high-frequency

characteristics of a high-speed device, there may be a fear that expected test results cannot be obtained.

To manufacture the contactor properly, there have been developed various technologies such as photolithography, etching, sputtering, plating, and other film forming technologies. Such a contactor is comprised of a contact terminal of, for example, a pyramid shape, a beam member supporting the contact terminal at its tip, a post supporting the beam member at its base end, and a board connected through the post. This contactor eliminates problems of a tungsten-made needle. Such a contact has a cantilever type structure in which the probe itself is fixed to the post. The contact terminal, the beam member, and the post of the probe are formed by their respective processes and undergo mechanical connection between the contact terminal and the beam member, that between the beam member and the post, and that between the post and the board by use of a means of, for example, transferring a wax material.

By a prior art method of manufacturing a contactor, its contact terminals, beam members, and posts are formed by different processes and then connected and unified. As a result, failure is liable to occur at the connection, leading to a problem of a lowered yield. Furthermore, this prior art suffers from many limitations; for example, the melting points

of various wax materials used at the connection at  
a plurality of positions must be changed properly.

For example, Jpn. Pat. Appln. KOKAI Publication  
No. 8-50146 discloses a contactor having a structure  
utilizing, as a buckling space, a groove formed in  
a lower part of the beam member (probe) having a  
contact terminal. Jpn. Pat. Appln. KOKAI Publication  
No. 11-133062 discloses a structure in which a post  
(supporting portion) is provided to reserve the  
buckling space of the beam member (lead portion) having  
the contact terminal. Such a probe card is disclosed  
that has a structure in which the beam member is  
connected on this post. In the former case, the  
contact terminal is comprised of a silicon core and  
a plurality of conductive films coating the core.  
Although the beam member can be formed at the same time  
as the conductive films of the contact terminal, the  
formation of the contact terminal and the beam member  
requires a plurality of processes. Since the beam  
member and the board are further interconnected through  
a different lead wire, the number of connections  
increases, thus resulting in an increased contact  
resistance at the connections. In the latter case,  
a process is required to form the post besides  
a process for forming the beam member and also the beam  
member is disposed on the board through the post, thus  
resulting in an increased contact resistance at

the connection.

The present invention solves at least one of the above-mentioned problems. One feature of one aspect of the present invention enables simplifying the processes of forming the contact terminal and the beam member.

Another feature of another aspect of the present invention enables obtaining a contactor with an improved reliability of the structure. A further feature of another aspect of the present invention enables providing a contactor which improves the high-frequency characteristics and enables conducting reliable testing, a probe card using the same, and a method for manufacturing the same. An additional

feature of another aspect of the present invention enables providing a probe card which enables surely conducting reliable testing even at a high temperature.

#### BRIEF SUMMARY OF THE INVENTION

According to a first aspect of the present invention, a contactor is provided for testing electric characteristics of an object to be tested. This contactor includes: a contactor board; a plurality of conductive members formed through the contactor board; a plurality of beam members each having a tip and a base end at its both ends in which at least a conductive layer is provided between both ends and each beam member has a step between its tip and base end, which is connected to each conductive member; and

a contact terminal member provided at the tip of each beam member in which the contact terminal member is formed integrally with the conductive layer of the beam member.

5            Preferably, the contact terminal member of this contactor is formed mainly of essentially the same material as the conductive layer of the beam member.

10           Preferably, the conductive layer of this contactor comprises one selected from the group consisting of nickel, copper, titanium, palladium, platinum, gold, tungsten, alloys of these metals, and metal compounds of these metals.

15           Preferably, the contact terminal member of this contactor is made of a high-hardness conductive metal, an alloy or metal compound thereof.

            Preferably, the high-hardness conductive metal of this contactor is selected from titanium, tungsten, and alloys and metal compounds thereof.

20           According to a second aspect of the present invention, a method for manufacturing the contactor is provided. This manufacturing method, for forming the beam member and the contact terminal member of this contactor, comprises the steps of: forming a recess in a silicon substrate, the recess having such a cross  
25           section that deepens according to a pattern corresponding to a step shape of the beam member and being deepest at its bottom; forming a silicon layer on

the recess; forming such a hole in the bottom that has  
a shape corresponding to the contact terminal member;  
and forming a film on the silicon layer and the side  
wall of the hole to constitute the conductive layer of  
5 the beam member and the contact terminal.

Preferably, the step of forming the silicon layer  
according to this method actually dopes boron.

Preferably, this manufacturing method further  
includes a step of directly joining the base end of the  
10 beam member to the conductive member of the contactor  
board.

Preferably, the joining by this manufacturing  
method comes in anode joining.

15 According to a third aspect of the present  
invention, a probe card is provided for testing the  
electric characteristics of an object to be tested.  
This probe card includes: a contactor according to the  
first aspect; a card board having a plurality of second  
conductive members arranged corresponding to the  
20 plurality of conductive members of the contactor; and  
an electric connection member interposed between the  
contactor and the card board. Of these components, the  
electric connection member serves to interconnect each  
of the conductive member of the contactor and each of  
25 the second conductive members of the card board.

Preferably, the electric connection member of this  
probe card has a cushioning structure.

Preferably, the electric connection member of this probe card is formed by a film forming process.

Preferably, the electric connection member of this probe card has an essentially  $\Omega$ -shaped structure.

5        Preferably, the contactor board of this probe card is of an insulating nature.

Preferably, an elastic film is interposed between the contactor board and the card board of this probe card.

10        According to a fourth aspect of the present invention, a contactor is provided which is used to test electric characteristics of an object to be tested. This contactor includes: a contactor board;

15        at least one conductive member formed through the contactor board; at least one beam member; and a contact terminal member provided at a tip of the beam member. Of these components, the beam member has one of a step shape and a slope shape and has its base end connected to the conductive member.

20        Preferably, the beam member of this contactor has a conductive layer formed thereon and its contact terminal member is formed integrally with the conductive layer of the beam member.

25        Preferably, the step-shaped beam member of this contactor is comprised of a plurality of step portions and a coupling portion for coupling them in such a configuration that at least one of the plurality of



coupling portion couples in an inclined manner the two step portions disposed above and below it.

Preferably, the conductive member of this contactor is frusto-conical in shape in such a configuration that the base end of the beam member is  
5 connected to one of the two surfaces, whichever is larger in area.

#### BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

FIG. 1 is a conceptual cross-sectional view for showing one embodiment of a probe card of the present invention;  
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FIG. 2 is an expanded cross-sectional view for showing a connection between a contactor and a card board of the probe card of FIG. 1;  
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FIG. 3 is an illustration for explaining operations of the probe card of FIG. 1;

FIGS. 4A and 4B are illustrations for indicating a state where first, second, and third recesses for making a probe are formed in a silicon substrate, of which FIG. 4A indicates a plan view and FIG. 4B, a cross-sectional view thereof;  
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FIGS. 5A and 5B are illustrations for showing a state where a delaminated layer of the probe is formed in the first, second, and third recesses of the silicon substrate, of which FIG. 5A indicates a plan view and FIG. 5B, a cross-sectional view thereof;  
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FIGS. 6A and 6B are illustrations for showing a

state where a bump mold is formed in the third recess (the deepest portion) of the silicon substrate of FIG. 5, of which FIG. 6A indicates a plan view and FIG. 6B, a cross-sectional view thereof;

5           FIGS. 7A and 7B are illustrations for showing a state where the probe is formed on a silicon layer of the silicon substrate of FIGS. 6A and 6B, of which FIG. 7A indicates a cross-sectional view of a state where a titanium carbonate film is formed on the  
10           silicon layer and FIG. 7B, a cross-sectional view of a state where a nickel film is formed on the titanium carbonate film;

          FIGS. 8A-8H are conceptual cross-sectional views showing steps of forming a conductive member on the  
15           card board in series;

          FIGS. 9A-9G are conceptual cross-sectional views for showing steps of forming an electric connection member on the card board of FIGS. 8A-8H in series;

          FIG. 10A is a cross-sectional view for showing a  
20           state where a probe formed on the silicon substrate and a conductive member of the card board are joined to each other and FIG. 10B, a cross-sectional view for showing a state where the silicon substrate is removed from the state of FIG. 10A;

25           FIG. 11 is a conceptual cross-sectional view for showing another embodiment of the probe card of the present invention; and

FIG. 12 is a conceptual cross-sectional view for showing a further embodiment of the probe card of the present invention.

#### DETAILED DESCRIPTION OF THE INVENTION

5           The following will describe an embodiment of the present invention with reference to FIGS. 1-10B. This embodiment is described with reference to a case where an IC chip is tested as formed on a semiconductor wafer. This case, however, is used only for  
10           explanation, and does not limit the present invention in any way.

          As shown in, for example, FIG. 1, a contactor of this embodiment includes a contactor board 11 made of glass etc., a plurality of conductive members 12 made  
15           of conductive metal such as aluminum, nickel, copper, etc. buried in through holes formed vertically through the contactor board 11, a plurality of beam members 13, and a contact terminal 14 (bump) provided at tips 13E of the beam members 13.

20           The conductive members 12 may take on a frusto-conical-shaped structure such as a circular frustum or pyramidal frustum. The beam member 13 may have a step-shaped or arch-shaped structure between a tip 13E and a base end 13B. If the beam member 13  
25           has a step-shaped structure, the structure includes a step portion 13C and a coupling portion 13D. This coupling portion 13D may have an inclined structure as

shown in FIG. 1. The beam member 13 may have a two-layer structure comprised of a silicon layer 13A and a conductive layer 13F. An example of an arch-shaped beam member is shown in FIGS. 11 and 12.

5 The conductive layer 13F may be made of a springy conductive metal. This conductive layer 13F may be made of any one metal appropriately selected from a group consisting of nickel, copper, titanium, palladium, platinum, gold, and tungsten and alloys and  
10 metal compounds thereof.

The surface of the contact terminal 14 may be made of a high-hardness conductive metal. This conductive metal may be titanium, tungsten, or a compound thereof.

The structure may be of a quadrangular pyramidal shape.

15 The bump 14 is formed on the tip 13E of the beam member 13 of this embodiment. The beam member 13 and the bump 14 are combined to form a cantilever type probe. This cantilever type probe can accommodate irregularities in height of the electrode pads of an IC  
20 chip. Level differences of the beam members 13 can be adjusted properly according to differences in needle pressure or height of the bumps 14.

Thus, as shown in FIG. 1, a probe card 20 includes a card board 21, a conductive member 22 formed in the  
25 card board 21, a wiring line 23 connected at the upper end of the conductive member 22, and the contactor 10 connected to the back side of the card board 21. This

wiring line 23 may be made of a conductive metal such as gold, copper, nickel, etc.

The conductive member 12 of the contactor 10 is connected to the conductive member 22 of the card board 21 through the electric connection member 16 which has a roughly  $\Omega$ -shaped cross section. This electric connection member 16 may be made of a springy metal such as nickel, nickel alloy, etc. Between the contact board 11 and the card board 21 may be disposed an elastic film 24. This elastic film 24 may be made of a heat-resistant resin such as a silicon resin etc. This elastic film 24 may be formed in essentially the same thickness as the height of the electric connection member 16 connected to the contact board 21. FIG. 2 shows an enlarged view of a connection (portion encircled in FIG. 1) between the contact board 11 and the card board 21.

As shown in FIG. 2, if the electric connection member 16 is formed as  $\Omega$ -shaped, it has its one leg 16A connected to the conductive member 12 of the contactor 10 and its protrusion 16B connected to the conductive member 22 of the card board 21. Although the other leg 16C is held by a regulation member 17, it is a free end fundamentally, thus providing a cushioning structure of the electric connection member 16. Even when both the contactor board 11 and the card board 21 expand thermally to thereby apply

a shearing stress on the electric connection member 16, its leg 16C can slide laterally as shown by an arrow in FIG. 2, thus absorbing this shearing stress. As a result, it is possible to avoid shifting, due to thermal expansion, of the position of the contact board 11 and the card board 21.

The regulation member 17 shown in FIG. 2 for regulating the movement of the free end of the electric connection member 16 may be made of a polyimide resin. If the contactor board 11 and the card board 21 are made of such materials that have nearly the same thermal expansion coefficients, the electric connection member 16 need not always be of the above-mentioned cushioning structure.

Next, the operations of the probe card of this embodiment are described with reference to FIG. 3. Once the probe card 20 is attached to a probing apparatus, a wafer W is moved just below the probe card 20 by a wafer chuck (not shown). An alignment mechanism (not shown) is used to align the contact terminals 14 of a probe 15 and electrode pads P of an IC chip formed on the wafer W with each other. After alignment, the wafer chuck as loaded with the wafer W rises to contact each of the electrode pads P with each of the contact terminals 14. Further, the wafer chuck is over-driven to thereby elevate the wafer W against a spring force of the beam member 13 as shown by

a dash-and-dot line and a thin line in FIG. 3.

The electrode pads P and the corresponding contact terminals 14 are thus interconnected with each other.

In this case, even with irregularities in height of

5 this plurality of electrode pads P, the beam member 13 formed in a step-shaped or arch-shaped elastic structure can be deformed elastically to thereby

10 accommodate differences in height of the electrode pads P, thus surely contacting the bump 14 and the electrode pad P electrically. In this state, a tester sends a testing signal through the wiring line 23 to the probe card 20. This input signal is applied to the IC chip through the conductive member 22, the electric

15 connection member 16, the conductive member 12, the probe 15, and the electrode pad P in this order. A measurement-result signal from the IC chip is input to the tester through the electrode pad P, the probe 15, the conductive member 12, the electric connection member 16, the conductive member 22, and the wiring  
20 line 23 in this order. Based on this measurement-result signal, the tester can surely test the electric characteristics of the IC chip. The elastic film 24 interposed between the contactor 10 and the card board 21 enables avoiding positional shifting due to thermal  
25 expansion of the contactor board 11 and the card board 21 even at a high temperature.

The following will describe one embodiment of

a contactor manufacturing method according to the present invention. An explanation of the method of manufacturing the contactor 10 may be divided into two steps; one of forming the probe 15 and the other of making the contactor board 11. In both steps, the deposition step may be employed.

First, the step of forming the probe 15 is described, followed by a description of the step of making the contactor board 11. The manufacturing processes are described with reference to a figure showing an enlarged part of the contactor.

The following will describe one example of manufacturing the probe 15 with reference to

FIGS. 4A-7B. First, a silicon substrate 100 is prepared. In this silicon substrate, the probe 15 is formed using a deposition process. On the silicon substrate 100 is then applied a photo-resist to form a photo-resist film. This photo-resist film is exposed and developed to form an opening (rectangular, for example) in the photo-resist film. An etchant (for example, buffered hydrofluoric acid obtained by mixing hydrofluoric acid and 40-percent ammonium fluoride aqueous solution at a ratio of 1:6) is used to etch the silicon substrate 100 starting from the opening in the photo-resist film. By this etching, as shown in FIGS. 4A and 4B, a first recess 101 is formed by etching to a depth of the thickness (e.g., 10  $\mu$ m) of



the conductive layer 13F of the beam member 13 (see FIG. 1). Then, the photo-resist film is removed.

Similarly, a second recess 102 is formed on the left side of the first recess 101. The second recess 102 may be formed to a depth of, for example, 80  $\mu\text{m}$ . By the same method, a third recess (deepest portion) 103 is formed on the left side of the second recess 102. The third recess (deepest portion) 103 may be formed to a depth of, for example, 150  $\mu\text{m}$ . By the above-mentioned steps, the first, second, and third recesses 101, 102, and 103 are formed in a step shape. The horizontal distance of a tapered surface between the first, second, and third recesses 101, 102, and 103 may each be 35  $\mu\text{m}$ .

After the first, second, and third recesses 101, 102, and 103 are thus formed, the silicon substrate 100 undergoes thermal oxidation on its surface to form a thermal-oxide film thereon. Then, on the surface of this thermal-oxide film is formed a photo-resist film. This photo-resist film is exposed and developed to form such an opening in the photo-resist film that accords to an array pattern of the beam members 13 of the contactor 10. An etchant (e.g., buffered hydrofluoric acid) is used to remove the thermal-oxide film from the opening according to the pattern of the beam members 13 as shown in FIGS. 5A and 5B. The thermal-oxide film 109 except on the opening is left non-removed.

The beam member 13 may measure, for example, 80  $\mu\text{m}$  in width.

After the photo-resist film is removed, a publicly known prior art method is used to dope boron from the back side of the silicon substrate 100. The silicon substrate 100 is etched until a boron-doped face appears. As a result, as shown in FIGS. 5A and 5B, boron is diffused to the silicon layer 13A, which provides a base end of the beam member 13 and the silicon substrate in the opening corresponding to the array pattern of the beam members 13 in the first, second, and third recesses 101, 102, and 103. The other portions on the silicon substrate 100 are covered by the thermal-oxide film 109 and so are prevented from having boron diffused therein.

Subsequently, a publicly known prior art CVD method is used to stack a silicon oxide film (not shown) on the silicon substrate 100. On its surface is formed a photo-resist film. This photo-resist film is exposed and developed to form such an opening in the photo-resist film on the third recess 103 that accords to the array pattern of the bumps 14. An etchant (e.g., buffered hydrofluoric acid) is used to etch off the silicon oxide film in the opening to then remove the photo-resist film. A potassium hydroxide aqueous solution is used to anisotropically etch off the silicon layer from the opening. By this etching, such

a reversed quadrangular frusto-pyramidal recess 105 that corresponds to the shape of the bump 14 is formed. This recess may take on any shape. Buffered hydrofluoric acid is used to remove the silicon oxide film to thereby expose, as shown in FIGS. 6A and 6B, the silicon layer 104 according to the array pattern of the beam members 13 and also form the recess 105 according to the array pattern of the bumps 14. Note here that the silicon layer 104 is hatched.

Subsequently, on the silicon substrate 100 is formed a photo-resist film 110. This photo-resist film is exposed and developed to form an opening in the recess 105 and such a portion of the photo-resist film

that is hatched in FIG. 6A. Throughout on the surface of the silicon substrate 100 is formed a high-hardness conductive metal film (titanium-carbonate film) 106 by sputtering (FIGS. 7A and 7B). The titanium carbonate film 106 except its portions corresponding to the probe 15 is removed by lifting off the photo-resist film.

As shown in FIG. 7A, after the remaining thermal-oxide film 109 is removed, a photo-resist film is formed on the silicon substrate 100. This photo-resist film is exposed and developed to form such an opening in the photo-resist film that corresponds to the probe 15.

A tough metal (e.g., nickel) 107 is sputtered to form a nickel film throughout the surface of the silicon substrate 100 (FIG. 7A). The photo-resist film is

lifted off to thereby remove the nickel film on the photo-resist film together, thus resultantly forming the beam member 13 and the contact terminal 14 of the probe 15 on the silicon substrate 100 as shown in FIG. 7B. The length of each side of the contact terminal 14 can be made in formation to have a value of, for example, 50  $\mu\text{m}$ . By the above-mentioned series of processes, it is possible to simultaneously form pluralities of the beam members 13 and the bumps 14 in a predetermined array pattern on the silicon substrate 100 integrally. Accordingly, the beam member 13 and the bump 14 are integrally formed using nickel. As a result, in contrast to the prior art case, no

foreign metal for connection is interposed between the beam member 13 and the contact terminal 14. This greatly improves the electric characteristics of the probe 15, especially a high-frequency characteristic. Since the contact terminal 14 is coated with the titanium carbonate film 106 having a minute crystal structure, it is not liable to be contaminated by, for example a metal oxide from the electrode pad, during testing.

The following will describe steps of manufacturing the contactor board 11 with reference to FIGS. 8A-8H and 9A-9G. A glass board is prepared as the contactor board 11. A process is described below for forming the conductive member 12 on the contactor board 11.

As shown in FIG. 8A, a nickel film (seed layer) 11A is formed by sputtering on the contactor board 11. This film serves as an underlying layer for plating. On it is formed a photo-resist film 11B. This photo-resist film 11B is exposed and developed to remove the photo-resist film 11B except the portions where the conductive member 12 is to be disposed, to expose the seed layer 11A (FIG. 8B). As shown in FIG. 8C, electrolytic plating utilizing the seed layer 11A as an electrode is conducted to form a nickel-plated layer 11C on the seed layer 11A.

As shown in FIG. 8D, a flaking solution (e.g., sulfuric acid aqueous solution, hydrogen peroxide solution, etc.) is used to remove the photo-resist film. As shown in FIG. 8D, by reactive ion etching, the exposed seed layer 11 and the underlying Pyrex glass are removed to form a through hole 11D having a forward-tapered cross section (such as shown in FIG. 8E). After the nickel-plated layer 11C is removed by an etchant (e.g., aqua regia, etc.) as shown in FIG. 8F, a metal plate 11E is applied to the back side of the contactor board 11 as shown in FIG. 8G. This metal plate covers the smaller opening of the through hole 11D. By conducting electrolytic plating using the metal plate 11E as an electrode, nickel metal is buried into the through hole from the right side of the contactor board 11 as shown in FIG. 8H, thus forming

the conductive member 12. The metal plate 11E is flaked off from the contactor board.

The following will describe a step of forming the  $\Omega$ -shaped electric connection member 16 using deposition processing on the surface of the contactor board 11 from which the metal plate 11E was thus flaked off. As shown in FIG. 9A, a negative photo-resist film 11F is formed. The negative photo-resist film 11F is exposed and developed to be left non-removed only where the electric connection member 16 is to protrude (FIG. 9A). As shown in FIG. 9B, a positive photo-resist film 11G is formed. The positive photo-resist film 11G is exposed and developed to form an opening therein where legs 16A and 16C of the electric connection member 16 are to be formed.

As shown in FIG. 9C, throughout the surface of the contactor board 11 where the photo-resist films 11F and 11G are formed is formed a seed layer (e.g., nickel) (not shown) by sputtering. Electrolytic plating is conducted to stack nickel-plated layer 11H on the seed layer.

As shown in FIG. 9D, the positive photo-resist film 11G is flaked off from the contactor board 11 to flake off also the overlying nickel-plated layer 11H together. Thus, the negative photo-resist 11F and such portions of the nickel-plated layer 11H that correspond to the electric connection member 16 remain.

As shown in FIG. 9E, throughout the surface where, for example, the electric connection member 16 is formed is formed a polyimide 11I. On it is formed a photo-resist film (not shown). This photo-resist film is exposed and developed to be removed except such portions thereof that correspond to the regulation member 17. Thus, as shown in FIG. 9F, the regulation member 17 made of the polyimide layer 11I is formed. The regulation member 17 serves to regulate the movement of the free end (leg 16C opposite to the conductive member 12) of the electric connection member 16.

Finally, to form the protrusion 16B of the electric connection member 16, the negative photo-resist film 11F is removed. As shown in FIG. 9G, it is possible to simultaneously form the electric connection member 16 and the regulation member 17 using a consistent step on the surface of the contactor board 11.

The following will describe a step of joining the probe 15 on the silicon substrate 100 and the conductive member 12 in the contactor board 11 with each other with reference to FIG. 10A. The side of the silicon substrate 100 where the probe 15 is formed is placed against the side opposite the side of the contactor board 11 where the electric connection member 16 is formed. As shown in FIG. 10A, the base end of

the beam member 13 is aligned with the conductive member 12. The base end 13B of the beam member 13 is joined to the contactor board 11. Preferably, they are joined not by an ordinary joining method but by a direct joining method. An example thereof is anode joining. By this joining, the base end 13B of the silicon layer 104 (13A) is directly joined to the contactor board 11. By removing the silicon substrate 100 from the contactor board 11, the beam member 13 and the bump 14 are flaked together with the silicon layer 104 from the silicon substrate 100. Thus, the contactor 10 is formed which is integrated with the probe comprised of the contactor board 11, the beam member 13, and the bump 14. The joining of the conductive member 12 of the contactor board 11 and the probe 15 is integrated by nickel, thus avoiding a foreign metal encroaching between the beam member 13 and the bump 14 in contrast to the prior art embodiment. This greatly improves the connection reliability of the contactor 10. Direct joining (e.g., anode joining) is used to similarly join the protrusion 16B of the electric connection member 16 of the contactor 10 and the second conductive member 22 (FIG. 2) of the card board 21, thus forming the probe card 20. During manufacturing of the probe card 20, it is possible to anode-join the contactor 10 and the card board 21 after, for example, the elastic film 24 is



formed on the card board 21 in a predetermined pattern to a predetermined film thickness. Since there is no foreign metal existing at the connection between the conductive member 22 of the card boards 21 and the contactor 10, the electric characteristics of the probe card, especially the high-frequency characteristic will be greatly improved. Measurement can be surely performed in the high-frequency band.

As described above, by this embodiment, the beam member 13 is formed along the contactor board 11 as separated therefrom in a step shape or arch shape. Since the bump 14 is formed integrally with the beam member 13 by the deposition process, it is possible to avoid influences such as contact resistance, electro-migration etc. between the beam member 13 and the bump 14. Measurement excellent in mechanical stability and high-frequency characteristics can be performed. By appropriately adjusting the length of the beam member 13, the probe card can accommodate a lower needle pressure. The contact terminal (e.g., bump) can be contacted to the electrode pad P without damaging the electrode pad P which can be made of gold, aluminum, copper, solder, etc. and also with a low contact resistance, in a stable manner. In a case where the beam member 13 is formed in a step shape, by appropriately adjusting the level difference between the steps, it is possible to properly adjust the amount

of overdriving of a test object. In a case where the beam member 13 and the bump 14 are formed by the deposition process, it is possible to create a fine probe pattern with a high accuracy. The probe 15 can be made of such an appropriate material having a high rigidity and a high specific resistance as nickel, copper, titanium, tungsten, or an alloy thereof. Since the beam member 13 and the bump 14 need not otherwise be connected, it is possible to avoid a decrease in yield due to a faulty connection therebetween. It is also possible to avoid limitations in manufacturing such as selection of a wax material. By coating the bump 14 with metal excellent in wear resistance (e.g., titanium carbonate), the service life of the probe 15 can be prolonged. Since these metals have a minute crystal structure, it is possible to prevent an impurity such as a contaminant from sticking to the surface thereof.

By this embodiment, by providing a cushioning structure of the electric connection member 16 for electrically interconnecting the contactor 10 and the card board 21, it is possible to accommodate a difference in size between the contactor board 11 and the card board 21 even when these two are different in thermal expansion coefficient. It is also possible to surely perform measurement even at a high temperature. Preferably, of course, the contactor board 11 and the

card board 21 are made of such materials that have nearly the same thermal expansion coefficients.

By this embodiment, when the beam member 13 and the bump 14 of the contactor 10 are manufactured, the first, second, and third recesses 101, 102, and 103 are formed by etching in the surface of the silicon board 100. Then, the silicon layer 104 having a pattern corresponding to the beam member 13 is formed on the surfaces of the first, second, and third recesses 101, 102, and 103. The recess 105 where the bump 14 is to be formed is formed at the tip of the deepest portion 103 of this silicon layer 104 and also, the beam member 13 and the bump are

formed simultaneously by performing deposition processing on the silicon layer 104 and the recess 105. Performing the deposition processing once is enough to integrally form the beam member 13 and the bump 14 in a step shape or an arch shape.

By this embodiment, the base end 13B of the beam member 13 is directly joined (e.g., anode-joined) near the conductive member 12 of the contactor board 11. The beam member 13 and the conductive member 12 are integrated by the same metal in structure. This improves the mechanical reliability and the high-frequency characteristics of the contactor 10.

By this embodiment, it is possible to form the electric connection member 16 by the deposition

process. The electric connection member 16 having a fine structure can also be manufactured in a secure manner.

5 The present invention is not limited at all to the above-mentioned embodiment. For example, although the above embodiment has been described with reference to a case where one contactor is made at a time, a plurality of contactors can be made also. Although it has been described with reference to a case of the probe card having one contactor, it is also possible to form a probe card having a plurality of contactors arrayed on one card board. The beam member need not have a stack structure. In short, any configuration is included in the scope of the present invention as far as it has the probe-component beam member formed as separated from the contactor board in a step or slope shape and also has the contact terminal and the beam member formed integrally.

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